PHYSICS OF LIFE AND DEATH

BY

Dr. RAMANNA

BHARATIYA VIDYA BHAVAN

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His Holiness Sri Kanchi Kamakoti Peetadhipathy Jagadguru

Sri Sankaracharya Chandrasekharendra Saraswati

Sathabhishekam Commemoration Lectures
(Fourth Series)

BY

Dr. R. RAMANNA
(Scientific adviser to Minister of Defence)

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The image of Sri Sankara Bhagavatpada
(in the Sri Kamakshi Shrine at Kanchi)

PUBLISHER'S NOTE

To commemorate the Sathabhishekam of His Holiness Sri Chandrasekharendra Saraswati Swamigal which took place on the 25th of February 1975. the *Bhavani Charitable Trust, Madras-6,* generously came forward with an Endowment for delivering lectures associating them with the name of His Holiness. The Bharatiya Vidya Bhavan, Madras Kendra, has gratefully accepted the Endowment.

The general scheme and purpose of the Endowment and some of the details of the spiritual ministry of the holy personage with whom it is associated will be found from the following pages i to vii,

The first lecture under this Endowment was delivered in English on the 12th and 13th of December 1975 by Dr. D.V. Gundappa on **Advaita-Faith and Practice** and has been published.

The second Endowment lecture, delivered in Samskrit on the 15th & 16th, December 1976 by Vidyanidhi Panditaraja, Vadasardula, Vidya Vachaspati, Pandita Ratna, Brahmasri V. S. Ramachandra Sastrigal, on "**The Advaitic Import of All Darsanas**", (*Sarvesham Darsananam Advaite Tatparyam*) has also been published along with a free translation in English by Dr. M. Narasimhachary.

The third Endowment lecture was delivered in Samskrit on the 11th of September 1977 by Pandita Praveena Vidvan Veereswara Krishna Dongre on "**Sri Sankara on Saguna Brahma**". (*Sri Sankara Bhagavat Padah Saguna Brahma Cha*).

OM

SRI GURUBHYO NAMAH

Sri Adi Sankara, reverentially adored as Sri Bhagavatpada, was a luminary of everlasting radiance in the spiritual firmament of India whose light has travelled through the centuries to the far corners of the globe.

After expounding the Truth of Advaita and securing its strength and solidarity on the firm foundation of his ***bhashyas*** on the ***Prasthanatraya***, to ensure that the tradition of his teachings was preserved and transmitted to future generations by precept and by example, Sri Sankara established, wherever his mission took him in Bharata Varsha, the ***sishyas*** that he had gathered under him through the years who could speak with the authentic voice of their discipleship to him and be exemplars of the way of life that he had promulgated. Such seats of religion were the Mutts or monasteries that he founded which, in course of time, grew to be bastions of the Vedic faith and practices and of the highest reaches of the Advaita philosophy. Of these, five have survived to this day, four in the cardinal corners of the country, and the fifth where, according to one tradition, he stayed in the closing years of his all too brief sojourn on earth and ultimately shuffled his vesture of clay. Through the years, they have been fulfilling their ordained purpose of transmitting the Sanskarite tradition undiminished by the passage of time. They functioned from Badari in the North, from Dwaraka in the West, from Puri in the East and from Sringeri in the South, and from the fifth one at Kanchi. Since the time of the great Original,* a succession of scholarly and holy personalities have presided over these monasteries which have acquired repute as Advaitic peethas.

*Though historians place Sri Sankara in the 8th Century A. D., the traditional date, according to the Monasteries, takes him to the B. Cs.

II

Of these, the Kamakoti Peetha at Kanchi counts sixtynine personages in pontifical succession to the great Sankara, all of them ripe scholars of Advaita, who transformed their knowledge into experiential anubhava, intense in their devotion to God whom they worshipped in the Yoga Linga of Sri Chandramouliswara, deeply committed to the spiritual education of their disciples and ever concerning themselves with their well-being. Among this galaxy of the renowned occupants of the Peetha, SRI CHANDRASEKHARENDRA SARASWATI SRICHARANAH the sixty-eighth in the line, is a person of superlative saintliness the like of whom one comes across only rarely. Called to his august Office in 1907 when he was barely thirteen years of age and initiated into the sannyasic order in a most unexpected way, the transformation overnight of Swaminatha, the High School lad, into Sankaracharya, the World Teacher, was as complete as it was instantaneous.

III

The details of the spiritual ministry of His Holiness, who is generally referred to and reverentially adored as ***Periyaval***, during these seven decades and more, have been as diverse as they have been extensively prolific. Deeply rooted in the belief ***Veda' khilo dharma-moolam,*** that the Vedas are the source and sanction of all of a man's dharmas, His Holiness has been anxious to establish the Vedas permanently in the utterance and understanding of those qualified to chant them and use them in the practices of their religion. Nothing has caused concern to His Holiness so much as the decline in the number of Vedic scholars and of those competent to officiate at sacramental ceremonies. To this end, he has organized All-India Institutions called the ***Veda dharma Sastra Paripalana Sabha*** and the ***Veda Rakshana Nidhi Trust***, reviving the declining practice of ***Veda Adhyayana*** particularly of those ***sakhas*** of the vedas whose adherents have dwindled in number in the passage of time. Similarly realising that any Vedic ritual performed with knowledge of the meaning of the mantras employed in it has its efficacy considerably enhanced, His Holiness encourages the study of ***Veda Bhashyas*** by public recognition of those adept in them and making cash awards both

to their teachers and students from time to time. The procedural details in the performance of the samskaras of every Hindu outlined in the *Dharma* and *Grihya Sutras* form subjects of study, the successful completion of which confers on the *vidyarthi* the title of *Dharmajna* or *Grihyajna* as the case may be, and also a cash prize. The *Sashtyabdapurti Trust* and the *kalavai Brindhavan Veda Vidya Trust* are dedicated to the furtherance of these schemes.

IV

The *Advaita Sabha* founded by his Paramaguru in 1895 has been functioning for over eighty years to promote the study of Advaita Vedanta and a pass in the examination held at the annual sessions of the Vidwat Sadas of the *Sabha* in different parts of the country under his patronage is a coveted distinction. His Holiness honours eminent scholars of Vedanta by the award of the prestigious title of **SASTRARATNAKARA**. As knowledge of Sanskrit is the foundation of all these acquisitions, His Holiness arranges that pupils are drawn to the study of that language in Schools and Colleges through the institution of *Amara Bharathi* which offers encouragement in the shape of scholarships and recognition of proficiency in the subject.

V

In the realm of religion, His Holiness has been stressing the performance of daily rituals like the *Sandhya Vandana* and allied observances and is keen that boys should have their *Upanayana* performed at the prescribed age before lustful thoughts impeding the growth of *Brahmatejas* find lodgement in their hearts. Emphasising the value of community worship in temples in addition to the domestic shrine, he has popularised the renovation of old temples and the construction and conservation of many new ones. For the proper ordering of such places of worship and to encourage the knowledge and practice of the *agamas* and the art of temple architecture, he has been giving a fillip to the traditional *sthapatis* and the practitioners of the *agamas* which regulate temple worship by holding periodic conferences which function as a clearing house of ideas and promote people's interest in and understanding of these cardinal features of temple worship.

VI

His Holiness has been endeavouring to promote intra-religious appreciation and amity between the *Saivaite* and the *Vaishnavaite* sections of the Hindus by insisting on *Siva-Vishnu-Abheda* making boys and girls sing the Vaishnavaite *Tiruppavai* and the Saivaite *Tiruvembavai* hymns and arranging Conferences for promoting equal devotion to these manifestations of the same God.

The system of weekly congregational paryers circumambulating the village temples known as *Vaaravazhipaadu* and the Ekadasi discourses in them, which His Holiness recommends, are intended to turn the mind Godward and to foster religious consciousness and habit among men.

VII

His Holiness has not been unmindful of the secular welfare of people both individually and collectively. Anxious to raise the standard of *life* (as distinct from our standard of *living*), he advises every one to cultivate simple habits, to avoid extravagance in marriage, to help indigent parents to perform in time the marriage of their daughters through the *Kanyakadana Trust* that he has commanded to be formed and to avoid the impoverishing practice of demanding dowries. His *Pidiarisi Thittam* is a masterstroke of genius by which every household donates just a handful of rice and a paisa every day to a common pool to help to cook the rice and distribute it after offering to God in a nearby temple to the needy poor who buy it for just a trifle of their earnings. His *Mudradhikari scheme* is intended to promote joint ventures by the people of a village in digging or deepening their tanks and the care of the village and its temple as a centre of religious and social life.

A group of his disciple is visiting hospitals periodically to distribute holy *prasadam* to the patients to hearten them in their sufferings and, where necessary, to enable the departing souls to take wing with *antima smarana* (lingering last thoughts) of their *ishta devata*. Another group visits prisoners in jails giving them counsel and comfort and reclaiming them as law-abiding citizens of society. Yet another service that is being rendered

by his instruction is the *jivatma kainkaryam* whereby the ultimate ceremonies are done to the forlorn dead *to each accordrng to the rites of his religion.*

VIII

His Holiness has also been endeavouring in his own way to bring about joint action by mathadhipatis of all denominations of Hindus to foster *astikya* and religious fervour among all classes of people without encroaching or ting deba on their theological doctrines and beliefs. He desires each one of us to observe the *anushthanas* appropriate to his nature, stage of life and status, and with a mlnd disciplined by the process. to be filled with devotion to God in the manner that *each one of us has been accustomed to worship Him by his Kulachara.*

IX

His Holiness' devotion to Sri Sankara is a rare example of *Gurubhakti.* He popularised the celebration of Sri Sankara Jayanthi in a scale unknown before his time and caused statues of Sri Sankara with his four disciples to be erected on elevated pedestals in important pilgrim places of India where people can have His saving *darshan* immediately after bathing in the sacred seas or rivers and worshipping in all the holy spots of the land. It has been a matter of great joy and satisfaction that a 125 feet high *Kirti Stupa* (consisting of nine storeys wherein the life-history of Adi Sankara and the details of his pilgrimage to various *Kshetras* are elaborately inscribed) has been sanctified by H. H. Sri Jayendra Saraswati on the Adi Sankara Jayanthi day in May 1978, at Kaladi, the birth place of Adi Sankara, to commemorate His avatar and achivements.

X

"In a country without a king, is not to be found the silent eremite who makes his home where the sun sets and walks

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* १. नाराजके जनपदे चरत्येकचरो वशी ।
भावयन्नात्मनात्मानं यत्र सायंगृहो मुनिः ॥
२. यानिशा सर्वभूतानां तस्यां जाग्रति संयमी ।
यस्यां जाग्रति भूतानि सा निशा पश्यतो मुनेः ॥

alone, his senses stilled, seeing the self in the Self" So say the counsellors of Dasaratha when the King is dead praying to Vasishta to see that there is no interregnum.* And the Lord tells Arjuna in the Bhagavad-Gita, "when it is night for all the world. the contemplative muni. who sees Blahman, is wide and awake."

These two statements between them may be said to present the Advatic state and its supreme relevance to the life and concerns of men. The jnani brings light and comfort by his mere presence. He is in the world but not of the world. He represents the ideal of impersonal benevolence and is a standing reminder to men that "the Kingdom of Heaven is within you".

In *His Holiness Sri Chandrasekharendra Saraswati Sricharanah* we have a supreme example of Advaita in precept and practice. Millions have basked in his presence and found in it balm for a wounded heart. The fortunate few have been helped to lift their eyes up above the horizon and glimpse the Truth of truths, thanks to the seasonable word they have been privilleged to hear. For them it has been a transporting experience and a permanent possession of immeasurable value. After relinquishing his pontificate to his successor Sri Jayendra Saraswathy Sripadah, whom he nominated to the Peetha in March 1954 and who is fulfilling the office with conspicuous success. His Holiness has, of late, been living, when he chooses to eat, only on uncooked food, be taken himself to *tapasya* and frequent spells of silence augmenting his spiritual eminence and benedictory greatness.

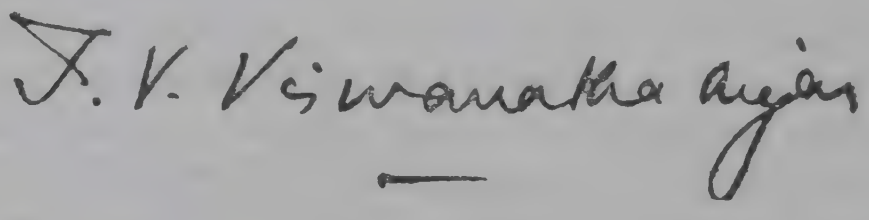
XI

It is therefore in the fitness of things that a sincere and self-effacing *sishya* of the Acharya should have come forward to endow an annual Lectureship under auspices of the *Madras Kendra* of the Bharatiya Vidya Bhavan through the agency of the *Bhavani Charitable Trust* associating it with the name of His Holiness to commemorate his *Satabhishekam* [his having witnessed the waxing (third day) moon a thousand times] to highlight the services of the Sage as the great exemplar of the life lived in the spirit of Advaita. The lectures (two or three in number to be delivered in one or more languages and at different centres) will lay special emphasis on the value of Advaita as a discipline for the making of the whole man, the ideal

represented by the words of Srimad Bhagavata '*sarvabhuta suhrt sadhuh maitrah karuna eva cha*', the man who befriends all life, who, having found the peace that passeth understanding, is full of the milk of human kindness and tender compassion.

It is intended that the lectures every year, which will be delivered by acknowledged authorities, should deal with on or more special aspects oi the large subject as it bears on ethics and religion as well as metaphysics.

The Bharatiya Vidya Bhavan (Madras Kendra) has appointed a Committee to be in charge of the Endowment to select and invite Lecturers, approve the subject, language and the centre (in India and abroad) and generally to carry out the purposes of the Endowment.



Chairman, Endowment Commmittee.

HIS HOLINESS SRI KANCHI KAMAKOTI PEETADHIPATHY JAGADGURU
SRI SANKARACHARYA CHANDRASEKHARENDRA SARASWATHI SWAMINAH

श्रीचन्द्रशेखरयतीन्द्रसरस्वतीनां शान्तान्तरङ्गकलितास्खिल भावकानाम् ।
काञ्चीपुरीस्थत महोन्नत कामकोटीपीठीमुपाश्रितवतां चरणाम्बुजानि ॥

PREFACE

This is the fourth in the series of the lectures delivered under the Bharatiya Vidya Bhavan's "His Holiness Sri Kanchi Kamakoti Peetadhipathy Jagadguru Sri Sankaracharya Chandrasekharendra Saraswathi Sathabhishekam Commemoration Lectures", founded by the munificence of the Bhavani Charitable Trust, Madras, delivered at the Madras Kendra of the Bharatiya Vidya Bhavan, on the 31st of July 1978.

The function began with prayer to the picture of His Holiness, Bhavan's prayer, Upanishad Parayanam and invocatory songs. Mr. T. V. Viswanatha Aiyar (Chairman of the Endowment Committee and Vice-Chairman of the Kendra) welcomed Dr. Raja Ramanna and the gathering, and pointed out that in His Holiness the Paramacharyal of Kanchi, we had a supreme example of Advaita in precept and practice and that a Jnani brings light and comfort by his mere presence. He is in the wold but not of it. He represents the idea of impersonal benevolence and a standing reminder to men that "the Kingdom of Heaven is within you". He referred to the creation of the Endowment to highlight the services of the Saint as a great exemplar of a life lived in the spirit of Advaita. He mentioned that Dr. Ramanna had been invited to deliver these lectures even two years ago but owing, apparently, to his preoccupation he could not do them then.

Dr. Raja Ramanna offering his obeisance to His Holiness and saying how blessed he felt by His darshan, referred to his article on Him in the Bhavan's Journal of August 28th 1977. He than mentioned that it was not because of his preoccupation that he did not deliver the lecture two years ago but really owing to his anxiety to choose a proper subject, befitting the occasion. He also referred to the excellence of the lectures delivered on the prior three occasions and his own difficulty in measuring up to that standard.

He then delivered the lecture to a very full house consisting of scholars and laymen.

Sri S. Narayanaswamy, (Vice Chairman of the Kendra) offered a Vote of Thanks.

PHYSICS OF LIFE AND DEATH

R. RAMANNA

—: :—

I have entitled this lecture "Physics of Life and Death", though it would have been more appropriate to call it "A physical view of the living and non-living systems". However. death implies a non-living system and the aim of the title is to stress the fact that Physics is now being applied with great rigour to the understanding of the mysterious behaviour of living systems. We recognise, particularly in man, the dramatic differences between a normal living body with the inherent consciousness in full play, controlling by means of external and internal feedbacks, its entire behaviour; a human body whose brain has been damaged by accident or disease and the integrated control mechanism missing but the individual cells internally still working coherently to retain the body as a living system: and a dead body which decays in a very short period of time to become unrecognisable from the environment except for some inanimate remains like bones etc. If materially these three phases are similar, where comes the difference. Is there a physical explanation to all this?

It has always been the ambition of scientists to explain as much as possible about life processes within the framework of existing laws of physics and chemistry. In recent times, great advances have been made in Bio-chemistry, Micro biology and Genetics. But, all these start with certain assumptions, particularly on the mysterious self-generating and protecting properties of biomolecules. It is only very recently the more fundamental aspects of physics have come to bear on the problem of how molecules by some sort of integrated processes permit evolutionary behaviour. It is the general feeling that a breakthrough has been achieved as to how the laws of physics. particularly thermodynamics, should be applied to the understanding of living systems. While we are certainly nowhere

near the final answers, we can say with some confidence that there does not seem to be any contradiction beween the existing laws of physics and the behaviour of molecules in bulk which mainfest life. This is indeed a very comprehensive statement to make, considering that till very recently it was thought that the laws of physics could not sustain an explanation for the autocatalytic behaviour of biomolecules, because it was in contradiction with one of the great cornerstones of mechanistic physics, i.e the second law of thermodynamics. The work of Prigogine and his collaborators over the last decade have brought to light the fact the second law has been used wrongly in understanding living systems and it requires a more generalised interpretation of thermodynamics to include what seemed impossible only a few years ago. In making these statements. we have to take into account the following facts.

A system which manifests life is like inanimate matter made up entirely of atoms and molecules, whose fundamental behaviour and systematics are reasonably well understood. In fact, nearly all biological processes are due to chemical reactions and depend on the nature of the chemical bond. It is this bond which is finally responsible for keeping the atoms and molecules together. and integrating them to become very large systems having properties of autocatalytic behaviour. This is very different from the views held in the past when it had always been thought hat there is something more than mere molecules in the operation of life processes. If we describe the processes of life in a thermodynamic sense, as we shall see later, it seems that the inverse square law due to electrostatic forces and the homopolar bond due to quantum mechanics and the added complexity of many body systems are sufficient to explain evolution in living systems.

Scientists in all branches of physics consider the law of conservation of energy as the most universal one, for it applies to phenomena right from those occurring at very large distances from us such as the ones we come across in astrophysics down to subatomic dimensions (fig. 1). Life processes are due to molecules whose dimensions are well within these two limits and it is unlikely that this great universal law will break down

in this region. If anything, it could have been different at the far edges of the universe or deep inside the atomic nucleus. All experiments to date indicate that whatever be the mysteries of life, it is not due to a violation of this law. We, however, note for the sake of completeness that in extremely small periods of time, it is impossible to verify this law due to uncertainity relations of Heisenberg and virtual processes not involving the energy conservation law are possible, but this paradox vanishes in periods of time during which a measurement is possible. These virtual processes do not in any way affect life bearing molecules and appear only in sub-atomic or particle physics.

I have already referred to the other fundamental law of macrophysics, viz the second law of thermodynamics. It is indeed one of the most exciting law in physics. It defines how the arrow of time is pointing and how isolated systems left to themselves tend to acquire maximum disorder or synonymously, that in systems left to themselves, the information about such systems decrease in time, because of growing disorder. All this is expressed by the physical term called Entropy, which is a measure of disorder or lack of information. The second law is often stated as follows:

"The entropy of the universe tends to a maximum" The second law also implies the irreversibility of certain types of operations in the physical world e.g., a glass sheet can easily be broken, but can never be brought back to its original state. In problems dealing with energy conversion from one form to another, it is stated in the following highly technical way:

> "It is not possible for a self-acting machine working in a cyclical process, unaided by an external agency, to make heat pass from one body to another at a higher temperature".

It is thus seen that the second law is indeed a cornerstone of physics and sets a limit to many physical operations. It also provides the basis of a scientific philosophy based on information theory. However, we note that the second law was hitherto considered only in systems which were in a state of equilibrium. As we will indicate later, it is in the release from this constraint

of equilibrium that new considerations have come into thermodynamics. What holds for a system under equilibrium does not necessarily hold for a system in conditions of non-equilibrium. Since the meaning of equilibrium is of vital importance in understanding the difference between living and non-living systems, a few words concerning equilibrium are necessary.

If we take a container containing any gas at a given temperature, we say it is in equilibrium if the velocities of the molecules of the gas have a certain specified distribution called the Maxwell-Boltzmann distribution (Fig. 2). In equilibrium, whatever the velocity of any given melocule, the overall distribution remains the same. The velocities of individual molecule may be changing constantly in time by collisions, but the overall distribution remains unaffected. It is in this sense we say that the system is in dynamic equilibrium. We also note here that the molecules of the gas in the container will be moving about in a random manner exhibiting the maximum disorder possible under the circumstances.

003 The second law also implies the irreversibility of physical processes. For example in the case of the gas in a container, we consider a situation where in the container only one side of it has the gas and the other side is in a state of vacuum separated by a membrane. If the membrane is suddenly removed the gas will diffuse into the vacuum region, but the inverse situation is not spontaneously possible. It will require considerable effort to have the gas occupy only a part of the container again and be separated from the vacuum. The inverse process means taking the state from one of higher disorder to a one of lower disorder. This can be achieved only by doing carefully planned work on the system. The only other possibility is by means of a contrivence which has a "subjective" feeling for the problem. This latter, if it can exist at all, is known as the "Maxwell Demon", named after the great physicist who first discussed it, and will be considered later.

I have chosen the molecules of a gas in a container for illustration of the state of equilibrium, but the same can be said of a system undergoing simultaneously several chemical reactions in different directions and equilibrium here implies that the final

quantity of the chemical constituents of the system statistically remain the same.

Thus, the second law states a system left to itself must degenerate to greater disorder and spontaneously (i.e. by itself) it cannot regain a higher order. Primafacie life processes seem to indicate that there is either a maintenance of order or achievement of higher order spontaneously in contradiction with the second law. Higher order is not reached just by supplying energy to a system though it is essential for such a process to take place. The supplied energy must be of the appropriate type and carefully designed for absorption. In the case of a living being. energy is supplied in the form of food. It is here one is tempted to invoke the role of the Demon of Maxwell to preserve or create order spontaneously with the use of "subjective" forces.

If in the gas container described above, we have a person endowed with special intelligence who can sort out by various ingenious devices those molecules which are fast from those which are slow, we can in principle produce order from disorder in contradiction with the second law. This is true provided the Demon is able to determine in good time the velocities of the molecules to arrange for the various devices to operate. Brillouin and others who have examined in great detail, several such possibilities, have shown that it is in the velocity determination, the Demon is bound to fail and it is indeed impossible to break the second law as long as the Demon uses physical methods to make his assessments and set up appropriate sorting systems. It seems, therefore, impossible for a Demon to operate in this manner and create order spontaneously. However, life processes require a person of this type. If, therefore, it is not possible for the ineffective Demon, restricted as he is by physical laws, to create cosmos out of chaos, could it be a more powerful being having supernatural powers? But is such an assumption necessary? Is it possible, while still remaining within the realms of Physics, we can explain life processes without the assumption of supernatual forces? We can at least try.

Any physical quantity which depends on several parameters departures from its normal expected value. These fluctuations exhibits are known as noise and are governed by the statistical

behaviour of the phenomena. All physical phenomena exhibit these departures to a greater or lesser extent and on rare occasions the departure may become very large. This happens in all probability games where one finds that on certain days, one is winning all the games or vice versa, but usually over a period of time the gain and losses are balanced out statistically. Our distinguished heart surgeon, Dr. Valiathan of Trivandrum was pointing out to me of the 'noise' in the construction of heart in various human beings. The many natural errors leading to heart insufficiency in human beings can be considered as 'noise' and, as we shall see later, can be interpreted as a process of evolution.

The existence of these probability fluctuation is of vital importance as this is the event that can lead to evolution and progress. Noise and fluctuation are due to probabilistic behaviour and are inescapable features of nature. It is unfortunate that probability is often associated with gambling even from the time of Rig Veda to Einstein himself, who is stated to have said in response to the probabilistic structure of quantum mechanics. "God is not a gambler". We now have to take a more non-emotional view of probability and may have to face the fact that the mystery of life is no different from the mystery of probability. The fact that you will never know the outcome of an event which depends on probability until it has taken place is sufficient mystery in itself.

Prigogine has shown that in systems which can be described thermodynamically and are not in equilibrium situations can exist, for a fluctuation to push it into a state where it can bifurcate itself and go over to a completely new state with all the properties of a new order. Hence in conditions of non-equilibrium, the possibility of producing higher order spontaneously exists, provided the system admits of multiple solutions which are stable in time and can be arrived at by a fluctuation. This can indeed happen in many chemical systemsw here conditions of nonequilibrium often exist and more so, because it is known that several chemical reactions proceed in a non-linear way. The methods used to demonstrate these possibilities are recondite, but it is sufficient here to refer to two familiar examples where higher order is established spontaneously through fluctuation in systems in a state of nonequilibrium.

The first is the familiar ringing of a microphone at public functions. Physically the state when it rings is a state of higher order because oscillations are set up at a fixed frequency. It is actuated by a fluctuation and is unpredictable, though everybody blames the poor technician incharge. The various feedbacks to the system create the nonequilibrium conditions.

The second is the more dramatic, oft-quoted example in Hydrodynamics. It is referred to as the Bernard problem. If a layer of liquid between two metal planes is subjected to a heat—gradient, it is found that at first the heat is merely transferred from one layer to other by conduction. If the heat gradient is increased, then all of a sudden, quite unpredicably the character of heat transfer is changed from a disorderly type to one exhibiting a surprising correlation among the molecules of the liquid. Fig. 3 is a photograph of the orderly convection that has suddenly come about, showing spontaneous correlation between a very large number of molecules.

These are comparatively simple cases, but one can imagine the several possibilities in complicated chemical processes where situations of this type can easily come about. We can, therefore, conclude that spontaneous activity found in life processes does not in any way contradict the laws of thermodynamics as we now know them today.

From this brief resume of recent developments we can assert that thermodynamics indeed allows for evolutionary behaviour i.e. a spontaneous movement from a lower order to higher order. The next question that arises is "Is there a physical theory of consciousness"? This is a difficult phenomenon to explain purely on molecular behaviour as it is difficult to define consciousness in clear physical terms. But we can make the following general statements:

If processes of life are due to molecules possessing autocatalytic properties, i.e. they are able to protect and help themselves, then the social behaviour of the lower animals can also be attributed to molecular activity.

We already know very definitely that our genetic behaviour is of molecular origin and one of the functions of autocatalytic

behaviour is to reproduce and protect its own species. Consider the case of ants. Many of the ants do not reproduce, but only exist to serve and protect its own species with a zeal that is proverbial. Can we conclude that the social behaviour of ants is an extension of genetic behaviour which in turn is due to the autocatalytic behaviour of life bearing molecules. One of the most remarkable behaviour among the higher animals is that of lemmings from whom we have a lot to learn. When the population of the lemmings gets beyond a certain number, several of them decide to commit suicide by jumping into the sea in the interest of the community. This must be regarded as a higher step in molecular consciousness.

It seems that all that I have said till now reflects the spirit of the Carvaka philosophers of this country. I must say that we have somewhat neglected their contentions all these years, but the ultimate question is scientific basis for Carvaka philosophy. or are we merely shifting the old problems of consciousness and reality to new jargon and new situations.

The new philosopy rightly places importance on observation, classification and generalisation, but uses the existence of processes such as molecular interaction, probability, fluctuation and autocatalytic behaviour. All these have a mathematical and physical description and can be parameterised in some form. but the corresponding implications remain unanswered. In molecular interactions, who created the inverse square law and by what process and for what purpose? In probability and fluctuation. we have the intangible of never being able to know when or what will happen, when finally decides the final outcome? And in biomolecular behaviour, why does it protect itself in the manner it does and is this the only solution possible? Is there a unity in all this or has everything come up in a random manner?

We also have to take note of the fact that we are asking these questions from within our own system and we know we can get paradoxical answers when we start asking questions about ourselves. Is our brain and perception big enough to understand all about ourselves particularly in the context of the overall unity of all phenomena?

This is the very question which has preoccupied the minds of many Indian philosophers. Is it not time that we understood the Vedas, Upanishads, Madhyamika, Advaita and other disputations in the light of modern developments in science. We now believe, we understand the material world much better than we ever did before and can therefore take a look at the ultimate questions, with a clearer background of material phenomena—not merely restricted to agricultural concepts of the past such as cattle, butter, milk etc. We now have to include items like quarks. quasers, heavy ions and genes.

If indeed even our consciousness is entirely due to molecular activity, we can ask, is there a way to change it and improve on it? After all, as things are, our perception could not have reached its maximum capacity. The very fact that so many of our actions are still conditioned by the reproductive molecular forces, usually called sex and survival force called selfishness, itself shows the limitations of our development. It, therefore, seems possible that there is scope for improving our processes of acquiring knowledge and our perception. This is possible in two ways either by chemical effects on our system i.e. by drugs, irradiations etc. or by the use of the natural evolutionary force which depends on integrated molecular effects, one of which is yoga. The former method, though dangerous will, I am sure, be continued in various laboratories. On the other hand, the old books are full of the methods of yoga, and I was happy to see recently an excellent book on one aspect of the subject by Shri B. K. S. Iyengar of Poona. The use of Yoga in its widest sense, to change our overall molecular behaviour requires a deeper study of philosophy, science and life processes and it is in this context that the works of Patanjali, Sankara and others become relevant. Unfortunately, there are a very large number of yoga quacks in the country who have confounded the issue. Yoga to give you a higher perception, not merely physical development, by improving on the behaviour of the concerned set of molecules should be our aim. This seems feasible and is quite within the concepts of science. The whole programme requires a comprehensive study of ancient thought and a bigger effort by India in all fields of science, be it to name a few, genetics, astrophysics, or particle physics, however expensive the programme might be. As I have said on some earlier occasions, poverty of ideas and lack of mate-

rial wealth should not come in the way of progress, or the goal of achieving a higher perception. But as we stand to-day, we are no further than the great verse of the Rig Veda:

"There was not the non-existent nor the existent then;
There was no air nor the heaven which is beyond.
What did it contain. Where? In whose protection?
Was there water, unfathomable, profund".
But, I hope the aim gets clearer each day.

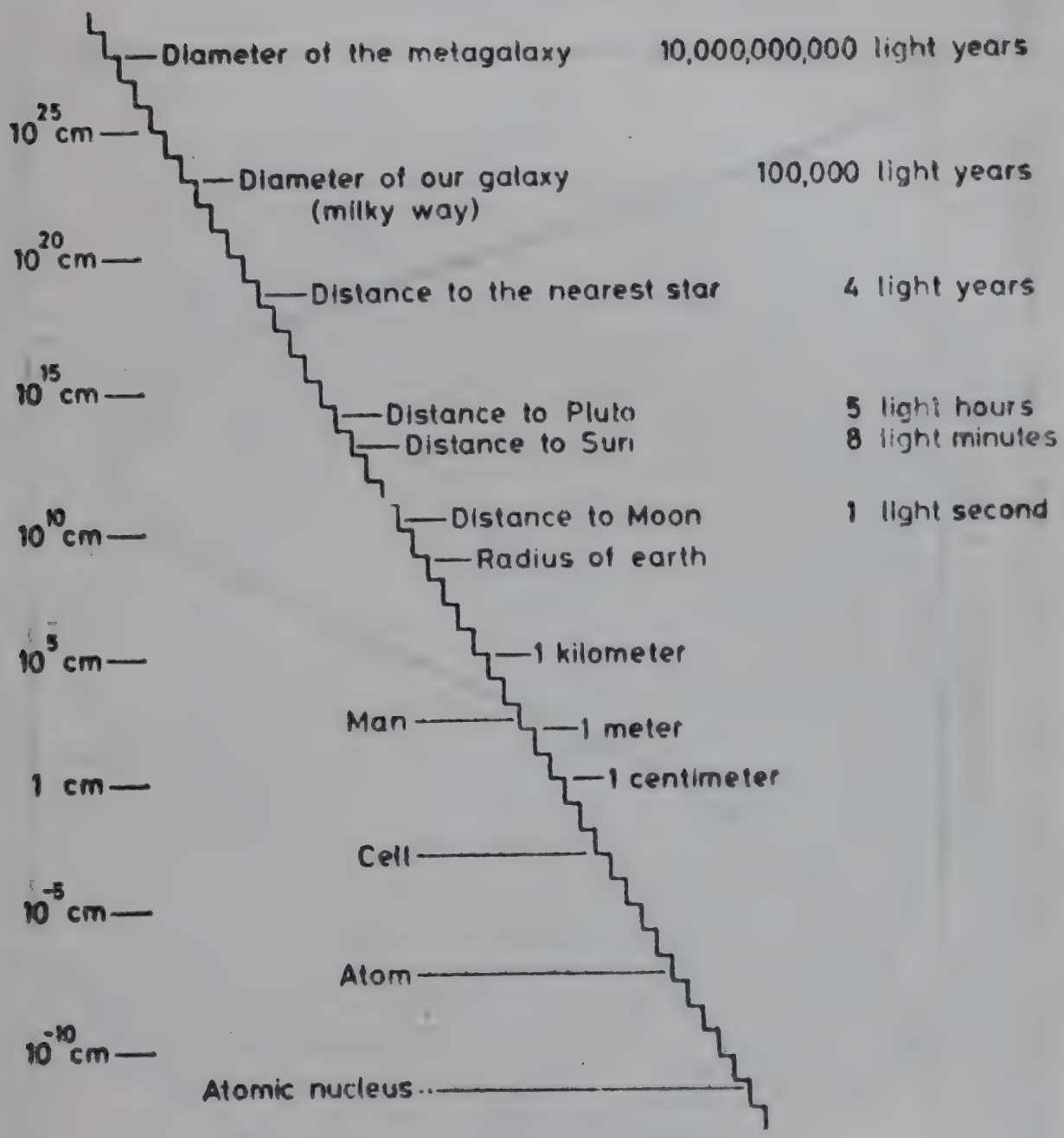

Diameter of the metagalaxy
10,000,000,000 light years
10^{25} cm
Diameter of our galaxy
(milky way)
100,000 light years
10^{20} cm
Distance to the nearest star
4 light years
10^{15} cm
Distance to Pluto
5 light hours
Distance to Sun
8 light minutes
Distance to Moon
1 light second
10^{10} cm
Radius of earth
10^{5} cm
1 kilometer
Man
1 meter
1 cm
1 centimeter
Cell
10^{-5} cm
Atom
10^{-10} cm
Atomic nucleus

Fig. 1

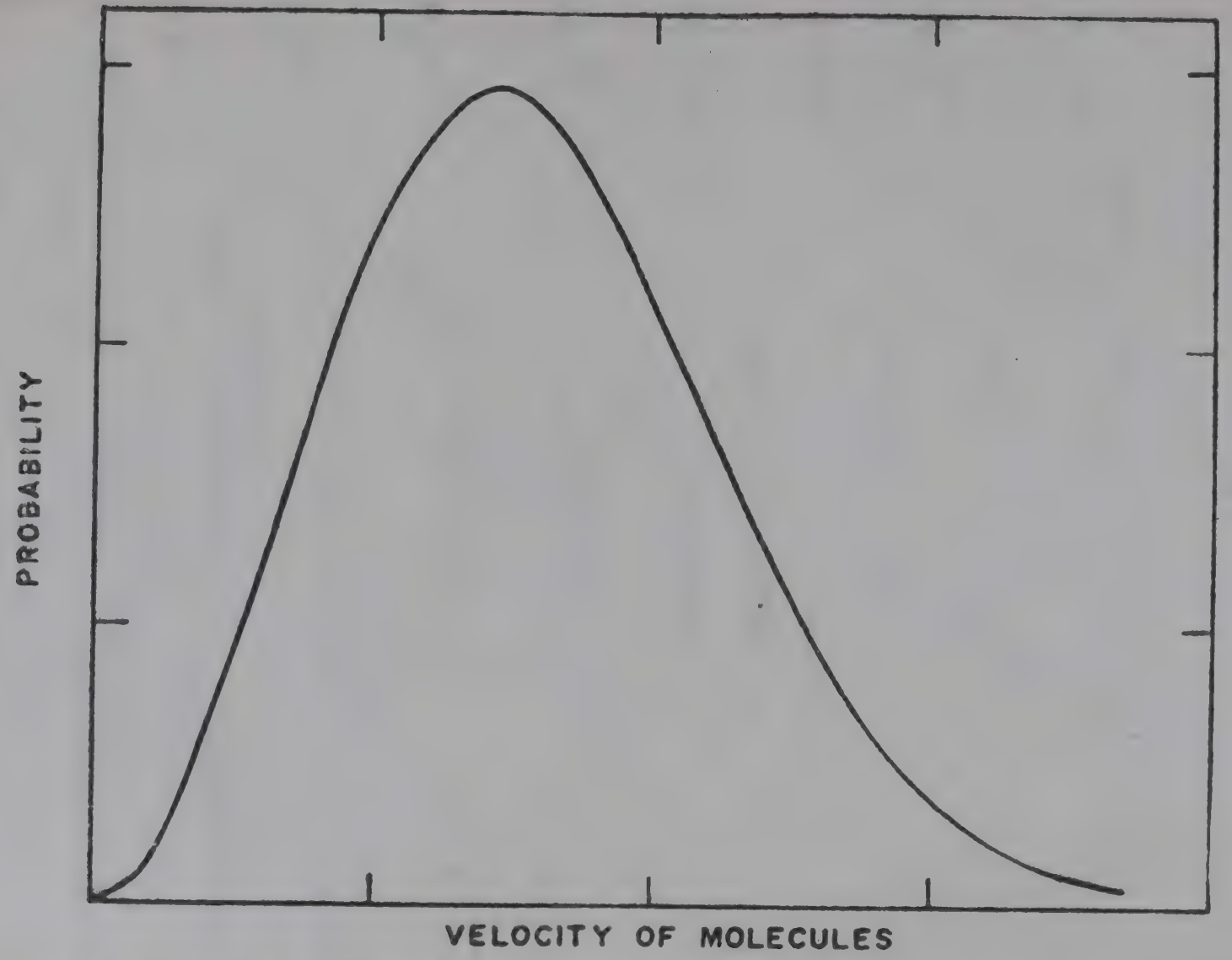


FIG. 2. DISTRIBUTION OF VELOCITIES OF MOLECULES IN EQUILIBRIUM

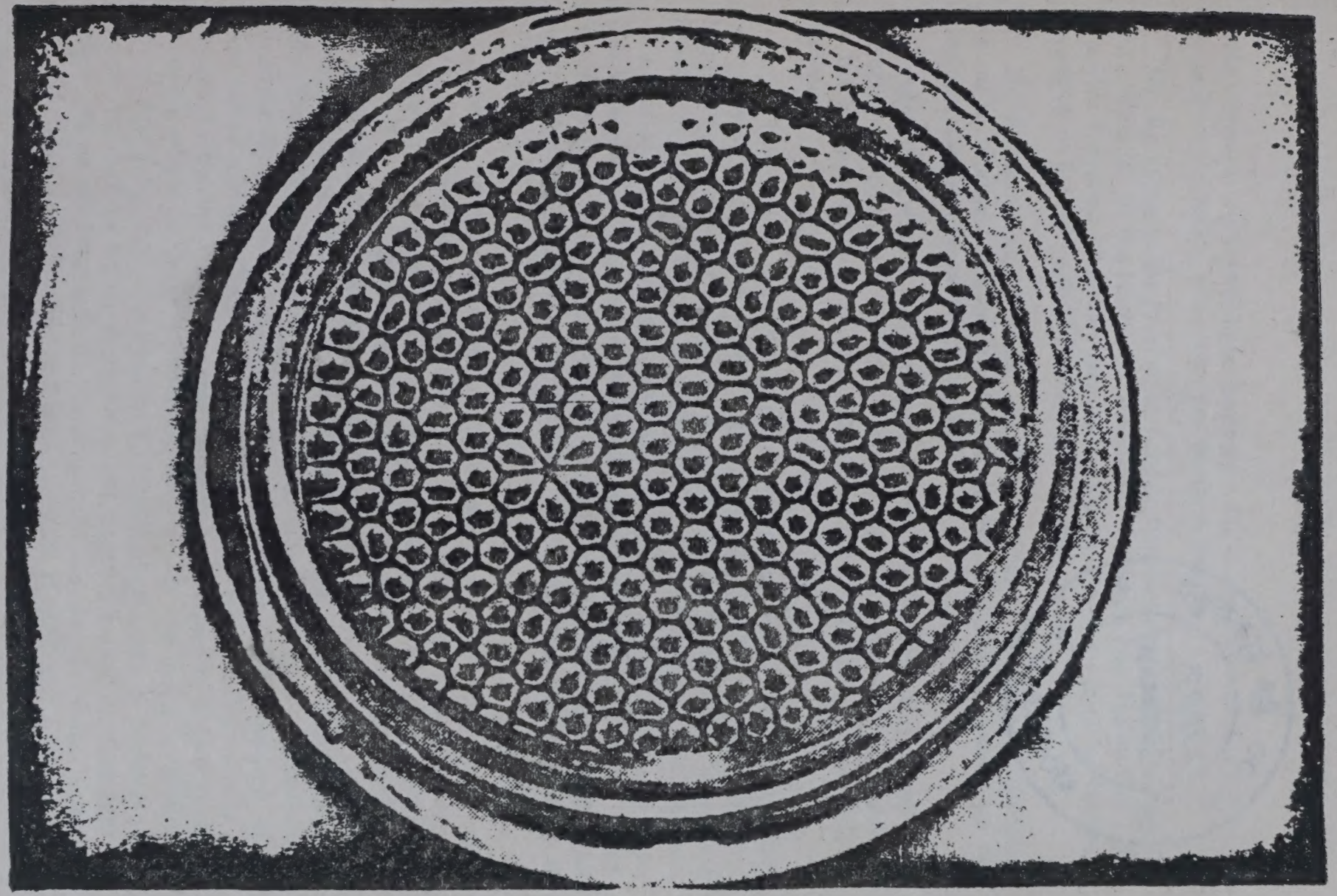


Fig. 3. Spontaneous Correlation between a very large number of Molecules.

Indian Institute of Technology, Bombay. He is the Chairman of All India Council for Technical Education for Western Region.

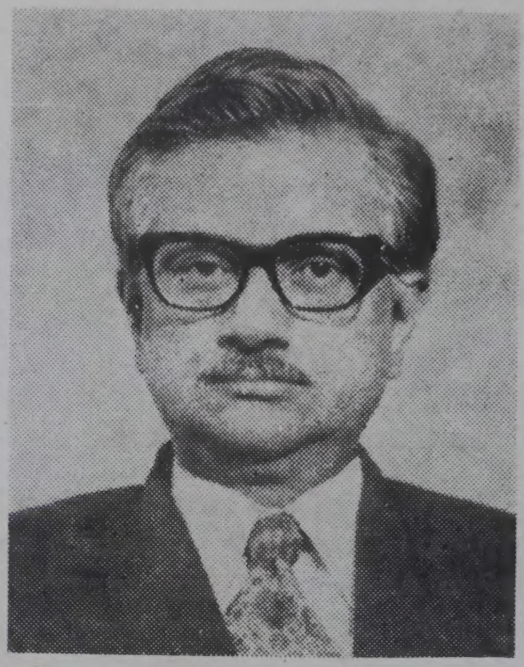
Dr. Ramanna is the President of the Indian National Science Academy and a Member of the National Committee on Science and Technology. He is a Vice-President of Indian Academy of Science and a Fellow of National Academy of Sciences and India Society of Engineers.

Dr. Ramanna was awarded the Shanti Swarup Bhatnagar Memorial Award for Physical Science in 1963 and the National Design Award of the Institution of Engineers (India) in 1974.

Presently Scientific Adviser to the Minister of Defence (Raksha Mantri), Director-General of the Defence Research and Development and Secretary to the Government of India in the Ministry of Defence for Defence Research.

In this lecture, the distinguised scientist stresses the fact that physics is now being applied with great vigour to the understanding of the mysterious behaviour of living systems. In fact it would be appropriate to call the lecture "A physical view of the living and non-living system". One can say with confidence that there does not seem to be any contradiction between the existing law of physics and the behaviour of molecules in bulk which manifest life. Is it possible while still remaining within the realms of Physics we can explain life processes without the assumption of supernatural forces ?

From recent developments one can assert that thermodynamics allows for evolutionary behaviour, i.e. a spontaneous movement from a lower order to a higher order. "Is there a physical theory of consciousness"? The new philosophy rightly places importance on observation, classification and generalisation, but uses the existence of processes such as molecular interaction, probability, fluctuation and autocatalystics behaviour. Is it not time that we understand the Vedas, Upanishads, Madhyamika, Advaita and other disputations in the light of modern development of science? There appears to be scope for improving our processes of acquiring knowledge and our preception either by chemical efforts on our system i.e., drugs, irradiation etc., or by the natual evolutionary force which depends on integrated molecular effects, one of which is yoga. Yoga to give one a higher preception, not merely physical development, by improving on the behaviour on the concerned set of molecules, should be the aim. This seems feasible and is quite within the concept of science. It is in this context the works of Patanjali, Shankara and others become relevant.



Dr. RAJA RAMANNA

Born in Mysore, January 28, 1925; early education at Bangalore B.Sc., (Hons.) from Madras University; Ph D., from London University; D.Sc, (Honoris Causa). Joined the Tata Institute of Fundamental Research in 1949 where he continues to hold the post of Senior Professor. Transferred to the erstwhile Atomic Energy Establishment (the present Bhabha Atomic Research Centre), Trombay in 1953 as Head of the Nuclear Physics Division. Was Director, Bhabha Atomic Research Centre and Member for Research and Development, Atomic Energy Commission from June, 1972 to June 30, 1978.

Dr. Ramanna had collaborated in the design, installation and commissioning of the Research Reactors, Apsara, Cirus and Purnima and the Cyclotron at Calcutta. He is the Chairman, Planning and Coordination Committee of the Reactor Research Centre at Kalpakkam, for planning and implementing a fast reactor programme for India.

Dr. Ramanna's scientific work has been on neutron thermalisation including pulsed neutron experiments, design of reactors and other neutron multiplying systems and experimental and the oriental studies on low energy nuclear reactions with special reference to Nuclear Fission.

Dr. Ramanna has participated in many international conferences at the U. N. level on the Peaceful Uses of Atomic Energy and was Chairman of several committees of national and international importance. He was Chairman of the NORA Committee for a joint project between the Norwegian Government and the International Atomic Energy Agency for the planning and programming of the zero energy reactor in Norway from its inception in 1960, and the India-Philippiness-Agency project committee for the utilisation of the research reactor at Manila for the study of Solid State Physics.

Dr, Ramanna was Chairman of the Board of Governors of Bharat Electronics Ltd., Bangalore. He was also the President of the Physics Section of the Golden Jubilee Session of the Indian Science Congress.

Dr. Ramanna is a Director of the Electronics Corporation of India, Limited, Hyderabad and the Chairman of the Board of Governors of

(Continued at the back)